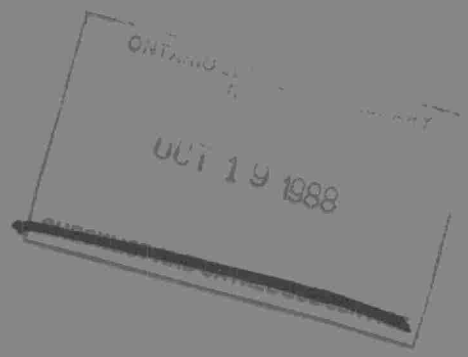
PHYTOTOXICOLOGY SURVEYS IN THE VICINITY OF INGLIS LIMITED STONEY CREEK



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Environment Ontario

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Minister

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Phytotoxicology Surveys in the Vicinity of Inglis Limited, Stoney Creek

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Report Abstract

Soil and vegetation sampling surveys have been conducted in the vicinity of Inglis Ltd., Stoney Creek Ontario from 1983. Boron Toxicity was noted to vegetation north of the plant and this was substantiated by excessive boron levels in the soil. A detailed soil sampling of soil on the company property in 1986 confirmed that boron was accumulating in the soil in proximity to the northern part of the plant. Although there are no clean-up guidelines for boron the degree and distribution of contamination suggest that boron toxicity may constitute a problem for establishing some types of vegetation on this site. Concentrations of cobalt marginally exceeded the recommended clean-up guideline (agricultural/residential/parkland) at 2 sites on company property but were below recommended levels for commercial/industrial development. No other clean-up guidelines were exceeded.

Résumé

Des échantillons de sol et de végétation sont prélevés depuis 1983 aux fins d'analyse à proximité de la Inglis Limited, à Stoney Creek (Ontario). Au nord de l'usine, nous avons remarqué des concentrations toxiques de bore dans la végétation, ce qui a été corroboré par des concentrations excessives dans le sol. Un échantillonnage extensif dans la propriété de l'entreprise en 1986 a confirmé l'accumulation de bore dans le sol à proximité de la partie septentrionale de l'usine. Bien qu'il n'existe aucune directive sur la décontamination en ce qui concerne le bore, le degré et la répartition de la contamination indiquent que les concentrations de bore peuvent constituer un problème si l'on veut introduire certains types de végétation en ce lieu. En deux endroits de la propriété, des concentrations de cobalt dépassaient très légèrement ce que recommandent les directives (pour l'agriculture, les résidences et les parcs), mais restaient en dessous des taux recommandés pour des aménagements commerciaux ou industriels. Aucune autre recommandation figurant dans les directives n'a été transgressée.

INTRODUCTION

In 1983, a survey was established in the vicinity of the appliance manufacturing operation of Inglis Ltd. located at Stoney Creek, Ontario. At that time, eight permanent foliage and soil sampling stations were established in the vicinity of the plant. Although no injury was recorded in 1983, a similar survey conducted in 1984 located vegetation with injury typical of boron toxicity. Elevated fluoride and boron concentrations were found in samples collected in close proximity to the plant.

In 1985, the surveillance activities were limited in scope but the full surveillance program was carried out in 1986. Also in 1986, a more detailed sampling program was conducted on the company's property as part of the site decommissioning process. This report summarizes the results of all of the activities carried out by the Phytotoxicology Section in the vicinity of the Inglis operation.

FIELD ACTIVITIES

In late August 1983, eight permanent foliage and soil sampling stations were established in the vicinity of Inglis, Stoney Creek. The same sampling stations were used again in early September, 1984. In 1985, the field activities were limited to sample collection at two of the stations; however, a new station was established south of the plant and a control location was chosen distant from the operation.

In 1986, visual assessment of injury was carried out in July. At this time, foliage samples were collected from basswood (Tilia americana) trees for experimental studies. In September, 1986, a full sampling program to collect soil and vegetation was carried out. At this time, one former station (Station 4) was deleted since broad-leaved trees were no longer available at that location. Two new stations (Stations 11 and 12) were added to compensate for this loss in coverage. Since there was no single tree species present at all stations, samples were

taken from existing trees; however, maple species were selected when possible. The actual species selected are included in Table 1.

The locations of the sampling stations with respect to the Inglis plant are listed as follows:

Site	Distance and direction from Inglis Ltd.
1	800 m NNW
2	600 m N
3	300 m NNE
4	450 m ESE
5	150 m W
6	100 m N
7	600 m SSW
8	750 m SW
9	500 m SSE
10	20 km N control
11	250 m E
12	250 m SE

The samples were brought to the Phytotoxicology Laboratory for processing prior to chemical analysis. Vegetation samples were oven-dried, ground in a Wiley mill and stored in glass bottles. Soil samples were air-dried, ground to pass through a 45-mesh sieve and stored in glass bottles. Chemical analyses were performed by the MOE Laboratory at Rexdale. All samples were analysed for boron while vegetation was analysed for fluoride content in 1983, 1984 and 1985. Samples collected in September, 1986 were also analysed for a suite of elements including iron, arsenic, cadmium, cobalt, chromium, copper, nickel, lead and zinc.

VISUAL ASSESSMENT

Although elevated boron concentrations were recorded at some locations, no evidence for boron toxicity was observed during the 1983 investigation. In September 1984, however, injury typical of boron toxicity

was observed to basswood foliage at Site 6 and to sugar maple foliage at Site 5. Similar injuries were observed at these same locations to the same species in both 1985 and 1986, suggesting that the problem was continuing.

FOLIAR ANALYSIS

The results of boron analysis of the tree foliage samples are presented in Table 1. It is evident that the highest boron concentrations were present in samples collected at Sites 3, 4, 5 and 6. These are the sites located nearest to the Inglis operation. The values at Site 6 were consistently the highest and correspond with the observed boron toxicity symptoms at that location. The boron concentrations exceeded the upper limit of normal concentration (175 ppm) for this element in foliage in an urban setting in all samples collected at Site 6 and in one or more collections made at Sites 3, 4 and 5. Collections of foliage made at all other sites contained boron in the normal concentration range.

The foliage analysis results for fluoride are shown in Table 2. Only basswood foliage collected at Site 6 contained fluoride at concentrations in excess of the upper limit of normal (35 ppm). Since basswood is a known accumulator of fluoride, the elevated fluoride values were not considered to be true indicators of contamination, and fluoride analyses were not performed in 1986.

The foliage analysis for the additional elements carried out in 1986 are tabulated in Table 3. Only one sample consisting of white ash foliage collected at Site 12 exceeded the "Upper Limit of Normal" for concentrations of any element. The source of the copper which was the element involved in this instance is unknown but apparently is not related to local soil contamination (see below). The value for zinc in sugar maple foliage collected at Site 9 is elevated in relation to all other foliage samples and is associated with elevated zinc concentrations in soil at this location. The elevation in soil zinc at this localized site could be due to contamination from galvanized fence wire or run-off from a nearby parking area. There was no indication of

contamination of vegetation by various metallic elements that could be related to emissions from the Inglis operation in this portion of the survey.

SOIL ANALYSIS

The boron concentrations measured in the soil samples are shown in Table 4. The boron values exceeded the 'Upper Limit of Normal' guideline of 15 ppm each year only at Site 6. In 1984, the guideline was marginally exceeded at Sites 3 and 7, while the guideline was matched at Sites 3 and 5 in 1983. This information clearly indicates that there is a build-up of boron in a localized area to the northeast of the Inglis operation. The elevated boron concentrations in soil match the elevated boron values in foliage as well as foliar injury.

In Table 5, the analytical results for a variety of other elements (1986 samples) are presented. With the exception of zinc at Site 9, the values for all elements are well within the Upper Limit of Normal guideline for the respective elements. The elevated zinc concentration was localized and was related to elevated zinc concentrations in maple foliage as discussed above.

DECOMMISSIONING SURVEY

Upon learning of plans for possible closure of the Inglis Limited operation at Stoney Creek, the Hamilton District Office of the Ministry of the Environment requested that a survey be completed prior to the decommissioning of the plant. This survey would establish, in detail, the present degree of contamination of the property. This survey was conducted on September 12, 1986. A total of 15 sample sites were selected on the Inglis property within the perimeter fence as shown in Figure 2. At each site, samples of soil were collected from depths of 0 to 5 cm and from 0 to 15 cm. The samples were analysed for boron plus the nine other metallic elements noted above. In addition, the samples from the 0-15 cm depth were extracted with boiling water and the extracts analysed for boron as an estimate of the amount of boron available to plant roots.

The results of the chemical analyses are presented in Table 6 and 7 for the 0 to 5 and 0 to 15 cm depths, respectively. With the exceptions of cobalt and nickel noted below and boron, the elements were mainly present in concentrations within the 'Upper Limit of Normal' guidelines. In general, the values for all elements were higher in the surface soil than in the deeper profile. The lower values for the 0 to 15 cm depth indicate that a dilution effect is occurring over the greater sampling depth. In any case, the differences are of limited practical significance except for boron.

The boron concentrations ranged from 6 to 334 ppm in the surface soils. Twelve of the 15 samples exceeded the 'Upper Limit of Normal' guideline of 15 ppm B. In the 0 to 15 cm profile, boron concentrations ranged from 3 to 268 ppm and eight samples exceeded the 'Upper Limit of Normal' guideline. The boron distribution pattern around the Inglis plant clearly shows that higher concentrations are associated with the northwest corner of the plant with the three highest values (over 300 ppm B) at Sites 107, 110 and 111.

The boron extract using the hot water technique indicates that five sample profiles had available boron in excess of 1 µg/g. Values in excess of 1 µg/g have been associated with boron toxicity to plants. The locations of samples with excessive extractable boron are Sites 110, 111 and 112 and possibly Sites 107 and 114. They are primarily associated with elevated total boron in samples taken around the northerly portion of the plant.

Cobalt concentrations exceeded the 'Upper Limit of Normal' guideline (25 ppm Co) at Sites 107, 110, 111 and 112. These are the same sites where the highest boron was measured. The elevated values are evident at these sites regardless of sampling depth, although the surface soils have a greater degree of contamination.

Nickel in the soil at most sites was normal; however, concentrations exceeded the 'Upper Limit of Normal' guideline at Sites 104 and 105 for the 0 to 5 cm depth and at Site 110 for the 0 to 15 cm profile. It is not possible to conclude that emissions from the Inglis Limited plant had any role in the scattered elevated concentrations of this element.

An assessment of the boron, cobalt and nickel values in terms of the clean-up guidelines recommended by the Phytotoxicology Section and included in the draft of "Guidelines for the Decommissioning and Clean-up of sites in Ontario - March, 1988 is presented in Table 8.

Table 8: Comparison of Soil Clean-up Guidelines with Soil Results from the Inglis Property - September, 1986.

Element	Criteria for Proposed Land Use		Site Nos. on Inglis Property in Excess of Clean-up Guidelines	
	A/R/P* µg/g*** - dry w.t.)	C/I**	A/R/P	C/I
B	NE	NE	-	-
Co	50	100	#107, #111	none
Ni	200	200	none	none

NE - not established

*A/R/P - agricultural/residential/parkland

**C/I - commercial/industrial

*** for medium and fine textured soils (≤ 70% sand &≥17% O.M.)

It is apparent that only 2 sites marginally exceeded the recommended clean-up level (based on phytotoxicity) for cobalt while none were in excess of the nickel clean-up level. Although there has been no guideline established for boron, it is apparent from the data (Table 7) that extractable (plant available) boron in excess of 1 µg/g (the concentration above which some vegetation injury could occur) was detected at 5 sites at sampling depths of 0-15 cm. Based on the total boron results for the 0-5 and 0-15 cm sample depths, even more sites would have exceeded the 1 µg/g hot water extractable value for the 0-5 cm depth had the extraction been performed on these samples.

SUMMARY

The Phytotoxicology Section of the Ontario Ministry of the Environment has carried out investigations of the possible effects of emissions on the terrestrial environment in the vicinity of the Inglis plant at Stoney Creek, Ontario. Sampling of soil and vegetation has been conducted from 1983 to 1986. The results from analysis indicates that the primary cause for concern is emissions of boron which are accumulating in the soil and vegetation in proximity to the northern portion of the plant. The elevated boron content in foliage of trees in this area has been associated with visible foliar toxicity symptoms since 1984. A study to document the degree of contamination of the plant site area was carried out in 1986 following the announcement of possible closure of the operation. Although there are no clean-up guidelines for boron,the distribution and degree of contamination of the plant site suggests that boron toxicity may constitute a problem for establishing some types of vegetation on the northern part of the property.

Concentrations of cobalt marginally exceeded the recommended clean-up guideline (agricultural/residential/parkland) at 2 sites on company property but were blow recommended levels for commercial/industrial development. No other clean-up guidelines were exceeded.

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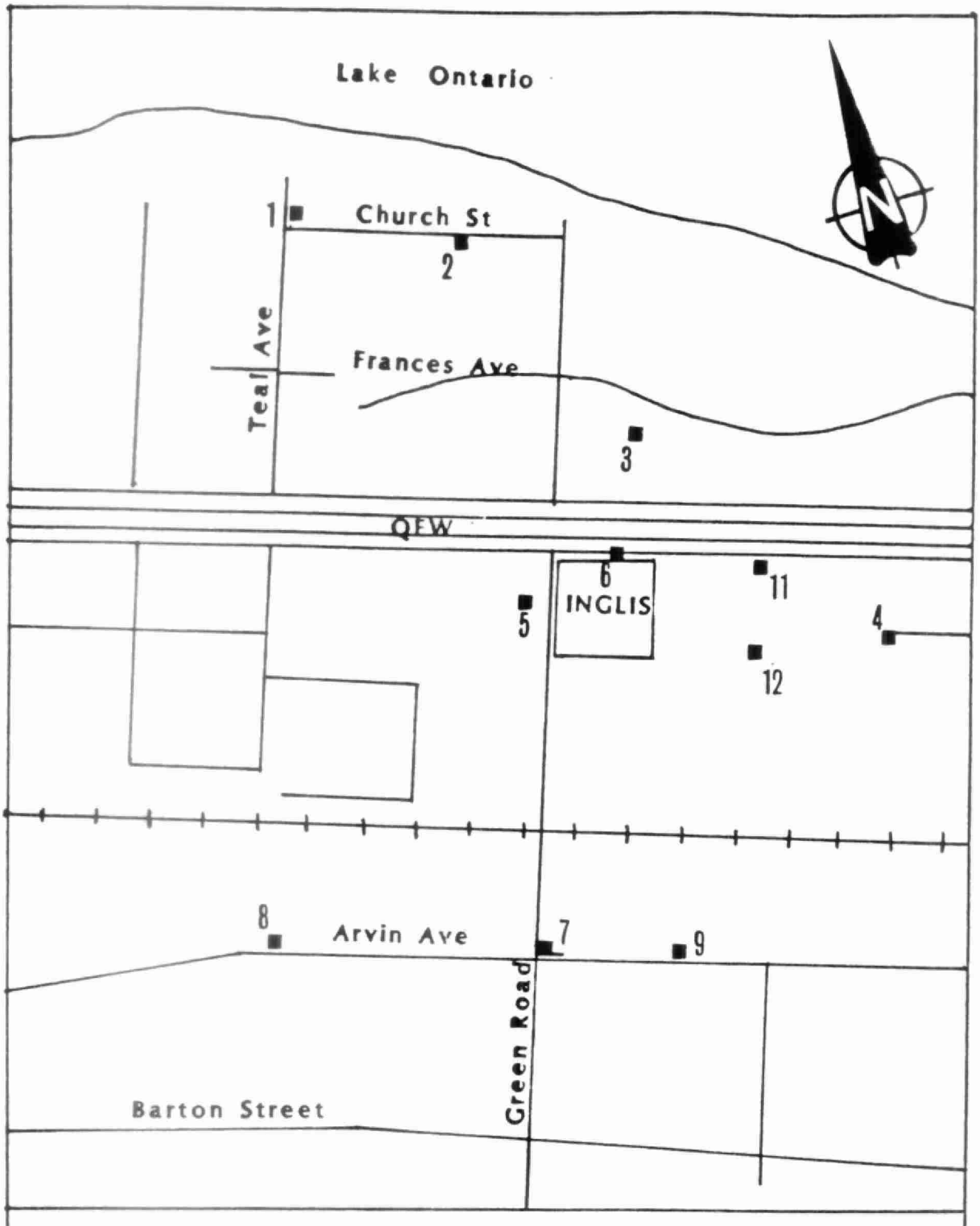

Figure 1. Locations of soil samples taken in the vicinity of Inglis Ltd, Stoney Creek 1983 to 1986

Figure 2. Locations of soil samples taken in proximity to Inglis Ltd., Stoney Creek during decommissioning study, September 1986

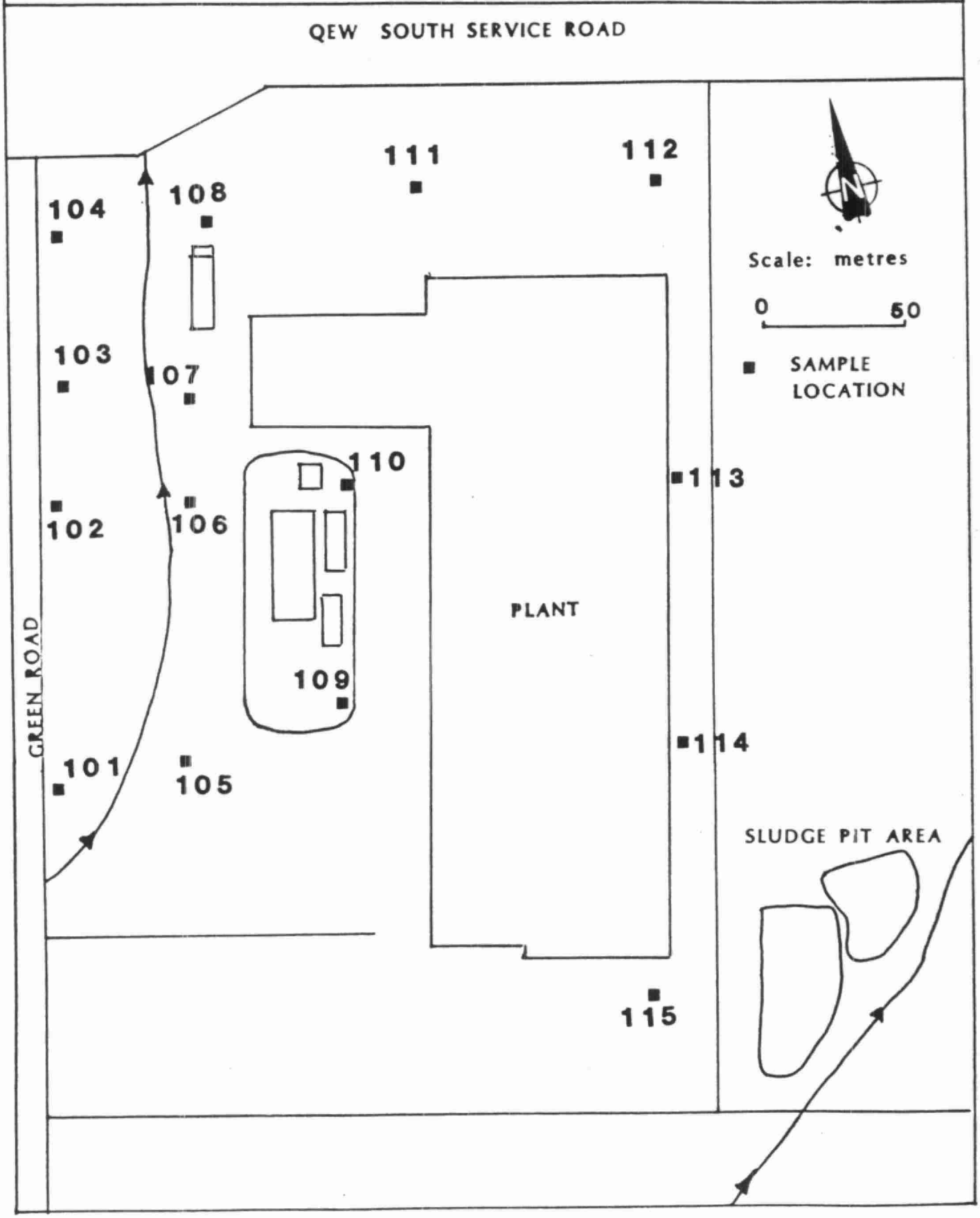

TABLE 1 - **Concentrations of Boron in Tree Foliage Samples Collected in the Vicinity of Inglis Limited, Stoney Creek - 1983 to 1986**

Station	Species	Concentration in Unwashed Foliage (ppm-dry wt.)				
		1983 Aug.	1984 Sept.	1985 Oct.	1986 July	1986 Sept.
1	Norway Maple	77	89	-*	-	89
2	Norway Maple	67	68	-	-	
	Silver Maple	-	-	-	-	28
3	Elm	181	190	-	-	-
	Basswood	-	-	130	135	220
4	Sugar Maple	94	200	-	-	-
5	Sugar Maple	216	200	190	-	160
6	Basswood	558	560	500	610	510
7	Silver Maple	79	77	-	-	70
8	Norway Maple	104	92	-	-	50
9	Sugar Maple	-	-	92	-	130
10	Basswood	-	-	57	73	76
10	Sugar Maple	-	-	44	-	57
10	Silver Maple	-	-	-	-	49
10	White Ash	-	-	-	-	36
11	White Ash	-	-	-	-	40
12	White Ash	-	-	-	-	35
Phytotoxicology "Upper Limit of Normal" for urban vegetation		-	-	175	-	

* not analyzed

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TABLE 2 - Concentrations of Fluoride in Tree Foliage Samples Collected in the Vicinity of Inglis Limited, Stoney Creek - 1983 to 1985

Station	Species	Concentration in Unwashed Tree Foliage (ppm-dry wt.) 1983	1984	1985
1	Norway Maple	5	6	-*
2	Norway Maple	3	11	-
3	Elm	13	34	-
3	Basswood	-	-	26
4	Sugar Maple	10	21	-
5	Sugar Maple	13	12	25
6	Basswood	180	110	134
7	Silver Maple	15	13	-
8	Norway Maple	30	16	-
9	Sugar Maple	-	-	20
10	Basswood	-	-	14
10	Sugar Maple	-	-	7
Phytotoxicology "Upper Limit of Normal" for urban vegetation		-	35	-

* not analyzed

TABLE 3 - Concentration of Various Chemical Elements in Tree Foliage Samples Collected in the Vicinity of Inglis Limited, Stoney Creek - September 15, 1986

Station	Species	Element Concentration (ppm-dry wt.)								
		Fe	As	Cd	Co	Cr	Cu	Ni	Pb	Zn
1	Norway Maple	190	0.16	<0.1	<1	1	6	<1	3	27
2	Norway Maple	130	0.10	<0.1	<1	<1	6	<1	2	27
3	Basswood	160	0.18	0.1	<1	2	5	<1	6	24
5	Sugar Maple	260	0.20	0.2	<1	2	7	<1	9	45
6	Basswood	260	0.24	0.2	<1	2	6	1	12	55
7	Silver Maple	550	0.38	0.2	<1	3	8	2	15	46
8	Norway Maple	280	0.35	0.3	<1	2	6	<1	7	25
9	Sugar Maple	360	0.22	0.2	<1	2	7	1	7	180
10	Basswood	120	0.16	0.1	<1	1	6	1	2	14
	Sugar maple	160	0.14	0.2	<1	1	3	<1	3	11
	Silver Maple	210	0.16	<0.1	<1	1	4	1	7	31
	White Ash	190	0.14	<0.1	<1	1	8	<1	3	11
11	White Ash	150	0.14	<0.1	<1	1	11	<1	5	31
12	White Ash	220	0.20	0.2	<1	2	26	1	4	39
Upper Limit of Normal		1000	2	3	2	8	20	7	60	500

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TABLE 4 - Concentrations of Boron in Soil Samples (0-5 cm) Collected in the Vicinity of Inglis Limited, Stoney Creek - 1983 to 1986

Station	Boron Concentration in Soil (ppm - dry wt.)			
	1983	1984	1985	1986
1	5	10		9.5
2	9	12		6.6
3	15	17		11.0
4	8	10		-
5	15	12	14	9.7
6	91	110	59	75.7
7	12	16		8.0
8	7	6		4.6
9	-	-		5.0
10	-	-	7	4.4
11	-	-		12.4
12	-	-		10.1
Phytotoxicology "Upper Limit of Normal" for urban soil	-	15		-

RE1899-T.4

TABLE 5 - Concentrations of Various Chemical Elements in Soil (0-5 cm) Samples Collected in the Vicinity of Inglis Limited, Stoney Creek - September 15, 1986

Station	Element Concentration (ppm - dry wt.)								
	Fe	As	Cd	Co	Cr	Cu	Ni	Pb	Zn
1	20000	4.8	<.2	7	28	25	16	49	125
2	18000	3.2	<.2	5	26	18	12	30	68
3	21000	5.5	<.2	8	29	24	16	25	76
5	19000	3.5	<.2	7	25	20	13	64	160
6	21000	5.7	.3	18	30	34	28	94	260
7	23000	5.1	.7	11	38	36	21	91	190
8	17000	4.3	.9	9	40	25	16	50	200
9	21000	5.5	.6	10	33	28	19	65	610
10	17000	4.6	.5	10	29	19	14	53	120
11	25000	4.6	.2	11	34	24	19	24	86
12	23000	12.0	1.2	11	31	29	22	170	93
Phytotoxicology Upper Limit of Normal for Urban Soil	35000	20	4	25	50	100	60	500	500

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TABLE 6 - Concentrations* of Chemical Elements in Soil (0-5 cm) Collected on the Inglis Limited Property, Stoney Creek, September 12, 1986.

Station No.	Boron Total	Iron	Arsenic	Cadmium	Cobalt	Chromium	Copper	Nickel	Lead	Zinc
101	13	23000	8.0	<0.2	9	30	27	56	59	98
102	45	24000	4.5	<0.2	12	34	30	19	51	120
103	74	23000	5.0	<0.2	18	35	42	22	61	140
104	6	23000	5.1	<0.2	8	32	29	86	120	100
105	23	22000	4.8	0.2	9	35	29	69	71	160
106	70	22000	6.0	0.3	17	37	33	42	61	160
107	310	22000	7.4	0.5	59	40	35	20	43	250
108	17	23000	5.6	<0.2	9	32	31	23	45	110
109	20	22000	5.3	<0.2	11	30	29	12	24	160
110	329	21000	7.7	1.0	41	37	45	22	33	490
111	334	19000	7.2	0.9	81	33	32	22	26	260
112	128	22000	5.9	0.8	31	34	36	25	28	180
113	22	21000	4.1	0.4	9	30	27	19	26	120
114	28	21000	3.7	0.9	9	34	30	22	27	180
115	8	17000	3.2	<0.2	5	22	31	23	29	100

*Concentrations expressed as parts of element per one million parts of air-dried soil by weight.

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TABLE 7 – Concentrations* of Chemical Elements in Soil (0-15 cm) Collected on the Inglis Limited Property, Stoney Creek, September 12, 1986.

Station No.	Boron Total	Extractable** Boron	Iron	Arsenic	Cadmium	Cobalt	Chromium	Copper	Nickel	Lead	Zinc
101	7	1	23000	5.1	0.4	12	32	30	22	33	100
102	29	<1	25000	4.5	0.2	10	31	28	22	26	86
103	41	1	25000	4.8	<0.2	12	33	35	25	28	97
104	4	<1	24000	4.5	0.3	7	27	27	19	26	120
105	4	1	25000	4.3	0.4	7	28	31	22	27	82
106	36	1	24000	5.0	0.3	11	30	33	23	29	110
107	196	2	22000	6.3	0.4	27	32	34	38	38	170
108	8	1	24000	5.7	0.2	8	30	28	19	35	130
109	9	1	22000	4.9	<0.2	9	30	27	20	34	100
110	268	9	21000	6.7	0.5	31	34	36	94	110	270
111	124	5	19000	5.1	0.2	26	29	27	35	41	130
112	55	4	25000	5.0	0.2	18	34	34	31	38	110
113	16	1	22000	3.8	<0.2	9	28	25	19	25	99
114	13	2	21000	3.4	0.3	7	31	24	21	30	130
115	3	1	18000	3.5	<0.2	6	23	22	12	24	96

*Concentrations expressed as parts of element per one million parts of air-dried soil by weight.

**boron extractable by hot water expressed as µg B/g soil.

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